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# Bibliography of research on UTILIZATION OF RICE in the Western Marketing and Nutrition Research Division

## 1947 - 1970

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THIS BIBLIOGRAPHY summarizes research publications and patents on utilization of rice from 1947 through 1970. Within the Western Marketing and Nutrition Research Division, studies on composition of rice and rice byproducts, development of new and improved rice foods, quality evaluation, and parboiling were conducted in the Field Crops and Cereals Laboratories. Drying, milling, and processing studies were made in cooperation with the Engineering and Development Laboratory. Waxy rice flour utilization was investigated chiefly in the Poultry Laboratory.

Supervisory staff members who have been associated with rice utilization research during organizational changes over the period covered are:

Division Directors: M. J. Copley, A. I. Morgan, Jr.
Laboratory Chiefs: (Cereals and Field Crops) F. P. Griffith, H. S. Olcott, K. W. Taylor (Acting), G. O. Kohler, J. W. Pence, D. A. Fellers; (Poultry) H. Lineweaver; (Engineering and Development) W. D. Ramage, A. H. Brown (Acting), A. I. Morgan, Jr., R. P. Graham
Investigation Heads: E. B. Kester, H. P. Binger, D. F. Houston (Acting), D. A. Fellers; Helen H. Palmer; A. H. Brown, G. S. Smith.

This bibliography was prepared in the Western Regional Research Laboratory by Dr. D. F. Houston, Research Chemist. Small supplies of reprints of recent publications mentioned are maintained, and single copies are available without charge. Photostat copies of publications for which reprints are not available can be purchased from the National Agricultural Library, U.S. Department of Agriculture, Beltsville, Md. 20705. Copies of patents must be purchased from the U.S. Patent Office, Washington, D.C., 20231, at 50 cents each domestically.

A copy of this publication is available from the Western Regional Research Laboratory, headquarters of the Western Marketing and Nutrition Research Division, USDA, Berkeley, Calif. 94710.

# ORGANIZATION

The Western Marketing and Nutrition Research Division (WMN) is part of the Agricultural Research Service (ARS) of the U.S. Department of Agriculture. Established in 1940, its headquarters and most laboratory facilities are located at the Western Regional Research Laboratory, 800 Buchanan Street, Albany, Calif. 94710. In addition, the Division supervises three outlying stations (see addresses below).

Offices of George W. Irving, Jr., Administrator of ARS, and F. R. Senti, Deputy Administrator for Marketing and Nutrition Research, are in Washington, D.C. Three other regional research divisions were also established in 1940 and are located in the eastern, northern, and southern parts of the United States. The Southeastern Agricultural Research Laboratory was established in 1969. Commodities assigned to WMN are western fruits (including citrus, other subtropical and tropical fruits); tree nuts; vegetables; poultry products; forage crops; wheat; rice and barley; wool and mohair; dry beans and peas; and castor, safflower, and other western oilseeds. (Rice research is also performed at the Southern Marketing and Nutrition Research Division, New Orleans, La.)

In the WMN, basic and applied research (chemical, physical, engineering, and economic) is directed toward these objectives: (1) To promote the utilization of farm commodities by increasing marketing efficiency and expanding exports; (2) to improve the quality of life by controlling the pollution of air and water from agricultural activities; (3) to assist in the development of rural America by promoting industry and new jobs; (4) to abate hunger and minimize the travail of poverty by improving the nutritional quality of foods and lowering their cost; and (5) to enhance the health and well-being of consumers by assuring the availability of safe, wholesome, and high-quality foods.

Field Laboratories

Fruit and Vegetable Chemistry Laboratory
263 South Chester Avenue
Pasadena, California 91106

Fruit and Vegetable Products Laboratory
c/o Western Washington Research and
Extension Center, Puyallup, Washington 98371

Hawaiian Fruit Laboratory
University of Hawaii
1920 Edmondson Road
Honolulu, Hawaii 96822

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# BIBLIOGRAPHY OF RESEARCH ON UTILIZATION OF RICE

## IN THE WESTERN MARKETING and NUTRITION RESEARCH DIVISION

1947-1970

## INTRODUCTION

Research on rice utilization in the U.S. Department of Agriculture at Albany, Calif., was begun in late 1947 on funds made available by the Research and Marketing Act of 1946. The program, later under general funding, has been in operation continuously since that time. Practical processing and development problems receive attention, as do more basic questions of composition and compositional changes in rice and its milling byproducts.

Early studies included the effects of moisture, temperature, aeration, and other storage conditions on the quality maintenance of stored rough rice. These studies were followed by comprehensive investigations of the effects of variables in drying of rough rice (paddy) on the milling quality and of the relation between harvest moisture and the milling and cooking qualities of the dried paddy and resulting milled rice. Information developed has aided in harvesting rice at an optimum stage and in maintaining quality through drying and storage operations. This information also enabled dryer operators to increase the efficiency and capacity of their existing equipment considerably. An effective sample dryer has been developed to aid in evaluating dryer operations.

Studies on brown rice established relations of milling damage, moisture, and storage temperature to maintenance of quality in this nutritious product. Moisture equilibrium data were also developed for brown and other edible forms of rice to determine the effects of relative humidity on storage in various climatic environments. These data have been helpful in the increasing volume of bulk shipment of brown rice.

Development of new or improved convenient forms of rice foods was also undertaken. This work resulted in new processes for preparing quick-cooking rice, canned cooked rice, instant brown rice hot cereal, a deep fat-fried rice snack item, and expanded rice suitable for cereals or snacks. Information was also developed on frozen cooked rice and on rice fortified by addition of lysine or soy protein. A new coating was developed to replace the nonnutritious talc now used in making coated rice. Conditions were also studied for parboiling medium grain California rice.

Recognition of the unusual pasting properties of flour from waxy or glutinous rices resulted in the development of white sauces and gravies that would withstand freezing and thawing. These sauces and gravies serve admirably in frozen precooked complete meals such as TV dinners.

Based on literature reports--particularly recent ones by Spanish investigators--that outer layers of the milled rice kernel were rich in protein and other nutrients, it appeared likely that nutritious high protein rice flours could be produced by abrasively milling off surface layers of the grain. Experiments with a small commercial abrasive whitener yielded flours with doubled protein content and with much enrichment in B-vitamins, lipids, and minerals. These results were confirmed in related work at the Southern Regional Research Laboratory, New Orleans, La. The flours offer a new nutritious rice ingredient for food uses.

Considerable basic information on rice composition has been developed. Amounts and distributions of proteins, amino acids, organic acids, and sugars and other carbohydrates have been determined and reported. Protein investigations have also included studies on the components of the protein mixture and their characteristics in both milled rice and bran. Information of this type is basic to many processing operations.

Attention has also been given to increasing the utilization of rice byproducts--straw, hulls, bran, and polish. Their effectively increased use can help to carry a greater part of milling costs than presently.

These and similar developments and related research are reported in detail in the technical publications listed here. Research on rice utilization is continuing. Additional papers will be published as results are achieved, so as to make the information available to the rice industry as quickly as possible.

# FOOD and PROCESSING

### RICE CURLS--A NEW FOOD PRODUCT FROM RICE

*R. L. Roberts, E. B. Kester and D. F. Houston*

U.S. Dept. Agr. AIC-258 mimeographed, Feb. 1950. Rice curls are a new snack food, comparable to potato chips or corn chips. They can be made inexpensively from broken rice, have excellent flavor, and store and handle well. The process for manufacturing them is simple: Ground rice is mixed with hot water to form a paste, which is extruded with suitable equipment. The resulting "curls" are cut to desired lengths and fried in vegetable oil. They make an attractive food specialty suitable for commercial production.

### RICE CURLS--PRODUCTION AND COST

*O. R. Vasak*

U.S. Dept. Agr. AIC-273 mimeographed, May 1950. From the 1950 data it was concluded that a plant with a capacity of not less than 150 to 300 pounds of rice curls per hour is desirable for commercial application of this process. As production capacity is increased, the cost of materials becomes the important factor in the total production and packaging cost. Factory burden and particularly labor costs are reduced considerably as size of operation is increased. In the 50-pound-per-hour operation, rice, cooking oil, and bags account for about 45 percent of the total production and packaging cost, but approximately 75 percent of the cost for the 300-pound-per-hour operation.

### FROZEN COOKED RICE

*Mildred M. Boggs, Catherine E. Sinnott, O. R. Vasak, and E. B. Kester*

Food Technol. 5(6): 230-232, June 1951. Frozen cooked rice was prepared by slowly boiling the rice in a small amount of water for 10 minutes and then steaming it for an additional 25 minutes, air cooling, packaging in cellophane, and freezing. It was stored for 1 week, 2 months, and 8 months at -23, -18.5 and -12°C (-10, 0, and 10°F.). Following storage the rice was prepared for the table in 10 minutes. Polished Texas Patna and California Pearl rice were used in the study. Tasters found the frozen rice fully equal to freshly cooked rice in every respect, even after 8 months of storage at -12°C. (10°F.). Estimates of manufacturing costs indicate that a 12-oz. carton of frozen cooked rice could be sold on the retail market for about 13 to 15 cents.

### EXPANDED RICE PRODUCT. A NEW USE FOR PARBOILED RICE

*R. L. Roberts, D. F. Houston, and E. B. Kester*

Food Technol. 5(9): 361-363, Sept. 1951. An expanded rice product is described which is a ready-to-eat cereal product made by heating dry parboiled rice in vegetable oil, shortening, or in a stream of hot air. The expanded crisp grains can be made rapidly and easily from commercially available raw material. Production would involve a single processing step in easily fabricated equipment. This product would offer an additional outlet for rice in the edible field.

### PREPARATION OF STABLE FROZEN SAUCES AND GRAVIES

*Helen L. Hanson, Agnes Campbell and Hans Lineweaver*

Food Technol. 5(10): 432-440, Oct. 1951. Study of the effects of a wide variety of conditions and substances (stabilizers, emulsifiers, or thickening agents) has provided basic information on factors that affect the stability of sauces and gravies subjected to freezing or frozen storage conditions. Varying degrees of improvement in stability were obtained with a number of the substances tested, but from all considerations the use of waxy rice flour as the thickening agent gave the most satisfactory sauce.

### FROZEN COOKED RICE. II. BROWN RICE

*Mildred M. Boggs, Alice C. Ward, Catherine E. Sinnott, and E. B. Kester*

Food Technol. 6(2): 53-54, Feb. 1952. Brown Pearl and brown Patna samples of rice were cooked with a measured volume of water for 15 minutes, steamed 50 minutes, then air-cooled, packaged, and frozen at -10°F. (-23.5°C.). They were stored at 0°F. (-18°C.) for periods of 1 week, 2 months, 6 months, and 12 months. The rice was prepared for serving by steaming for 10 minutes. Judges found the rice scarcely distinguishable from freshly cooked rice in every respect even after one year of storage.

### PREPARATION OF STABLE FROZEN PUDDING

*Helen Hanson, K. D. Nishita, and H. Lineweaver*

Food Technol. 7(11): 462-465, Nov. 1953. Preparation of desserts of a cornstarch-pudding or soft-custard consistency that are stable to freezing and limited frozen storage is described. Elimination of the separation and curdled appearance of products prepared by the usual formulas is accomplished by substitution of waxy rice flour for part or all of the usual thickening agents.

### PROCESS FOR CANNING WHITE RICE

*R. L. Roberts, D. F. Houston, and E. B. Kester*

Food Technol. 7(2):78-80, Feb. 1953. A process for preparing a high-quality canned white rice has been developed. The product is made by soaking the raw grain, boiling until the moisture content is about 55%, canning under high vacuum, and retorting. The raw material for this process is white rice instead of the parboiled rice used currently for commercially canned rice products. The desirable brilliant white color and typical rice flavor are retained. The grains remain well separated and do not become distorted or mushy in appearance. The canned rice is prepared for serving by heating in boiling water for only one minute, whereas 20 to 40 minutes are required to cook dry rice by the usual household methods.

CANNED COOKED RICE; THE MARKET POTENTIAL FOR A NEW FOOD PRODUCT
*R. V. Enochian, J. S. Hunter, and R. G. Harris*
(Agricultural Marketing Service in collaboration with Western Regional Research Laboratory)
U.S. Dept. Agr. Market. Res. Report No. 249, processed, 1958.
A new, easy-to-prepare, cooked and canned rice has been market-tested under the name of "Insta Rice". Results show that if Insta Rice were made available and promoted to the extent of other rice products it would equal them in sales.

REDUCTION OF COHESION IN CANNED PEARL RICE BY USE OF EDIBLE OIL EMULSIONS AND SURFACTANTS
*R. E. Ferrel and E. B. Kester*
Food Technol. 13(8): 473-474, Aug. 1959.
Results of experiments show superiority of the emulsion-treated rice over the untreated product in removability from cans and easy crumbling.

USE OF EMULSIFIERS AND EMULSIFIED OILS TO REDUCE COHESION IN CANNED WHITE RICE
*R. E. Ferrel, E. B. Kester, and James W. Pence*
Food Technol. 14(2): 102-105, Feb. 1960.
A rinse treatment with dilute vegetable oil emulsions or dilute dispersions of certain edible surface active agents during canning of short-grain rice markedly reduced cohesion that normally develops in the product.

SALAD DRESSINGS STABLE TO FROZEN STORAGE
*Helen L. Hanson and Lorraine R. Fletcher*
Food Technol. 15(5): 256-262, May 1961.
Factors considered in the investigations were oils, emulsifying agents, thickening agents, salt levels, and emulsion-paste ratios.

USE OF THE AMYLOGRAPH TO DETERMINE EXTENT OF COOKING IN STEAMED RICE
*R. E. Ferrel and J. W. Pence*
Cereal Chem. 41(1): 1-9, Jan. 1964.
Slurries of raw rice flour heated in the amylograph bowl to 90°C. and held for 20 minutes exhibit the marked reduction in viscosity common to starch materials held at this temperature. This difference in viscosity ($\Delta V$) decreases as steaming or other cooking pretreatment of rice is increased, until it reaches zero. Visual and other examination of steamed grain indicates that when $\Delta V$ reaches zero, the rice is completely cooked, internal opacity is minimal, and actual or potential starch-granule collapse apparently is near a maximum.

HIGH-PROTEIN RICE FLOURS
*David F. Houston, Ali Mohammad, Theodore Wasserman, and E. B. Kester*
Cereal Chem. 41(6): 514-523, Nov. 1964.
High protein flours were prepared by two types of commercial machinery. One process (fine-grinding and air classification) furnished 8 to 10 percent of the kernels as flour with about 75 percent higher protein, intermediate fractions, and 75 to 80 percent residual flour with slightly less protein than the original. Protein content was highest in the finest particles and decreased with increasing particle size. The second process was scouring consecutive layers in a continuous-flow abrasive cone mill. Flour from the outermost layers had about twice the protein content of the whole kernels, and was obtained in 10 to 15 percent yield. The residue was kernels of slightly reduced size and protein content, with some broken. Fat, ash, thiamine, riboflavin, and amylase activity followed the trend of protein content in each method.

WHITER WHEAT, MORE NUTRITIOUS RICE, BETTER BARLEY
*A. I. Morgan, Jr., E. J. Barta, and R. P. Graham*
Food Proc./Marketing 26(11): 98-100, Nov. 1965.
New white, unmilled cereals can be produced from parboiled wheat, barley, rice, and several other grains by chemical peeling. The product retains all the endosperm, including the nutritious aleurone layer, but loses most or all of the colored bran layers. The bran is loosened by strong warm lye, then removed by vigorous water washing. Warm dilute acid restores the surface whiteness. The grain is dried in warm air. A continuous automatic pilot plant is now in operation.

NEW RICE COATING MATERIALS
*R. E. Ferrel, G. O. Kohler, and R. R. Mickus*
(Calif. Rice Growers Assoc., Sacramento).
Rice Journal 69(2): 11-12, 14-15, Feb. 1966.
Several classes of materials were screened to find suitable replacements for the talc used in sheen-coating rice. Calcium salts of several organic acids appeared most promising. Preliminary trials with calcium acetate and calcium citrate in standard plant equipment and procedures indicate that they could be successfully used with only minor modification in present techniques. Panels could not distinguish by taste the acetate- and citrate-coated samples from uncoated rice of the same lot. Other advantages of the organic acid salts are calcium supplementation and elimination of the need to rinse coated rice.

CHEMICAL PEELING OF GRAIN
*A. I. Morgan, Jr., E. J. Barta, and R. P. Graham.*
Chemical Engineering Progress Symposium Series 62(69): 138-141, 1966; also in Fourth National Conference on Wheat Utilization Research, U.S. Dept. Agr. ARS 74-25, pp 27-31, April 1966.

New, white, unmilled cereals can be produced from wheat and several other grains by chemical peeling. The product retains all the endosperm, including the nutritious aleurone layer, but loses most or all of the colored bran layers. The bran is loosened by strong warm lye and then removed by vigorous water washing. Warm dilute acid restores the surface whiteness and the grain is dried in warm air. A continuous automatic pilot plant is now in operation at Albany, California.

### HIGH-PROTEIN FLOUR CAN BE MADE FROM ALL TYPES OF MILLED RICE

*D. F. Houston*

Rice Journal 70(9): 12-15, Aug. 1967.

Rice flours with about double the protein occurring in the original milled rices have been prepared from six widely differing types of rice by milling off the outer layers with a small commercial abrasive-type rice whitener. The results, together with previously published and extensive corroborating unpublished data, are strong evidence that the process is applicable to all types of rice.

### PROTEIN-FORTIFIED GRAIN PRODUCTS FOR WORLD USE

*F. R. Senti, M. J. Copley, and J. W. Pence*

Cereal Science Today 12(10): 426, 428-430, 441, Oct. 1967.

Cereal grains, legumes, and oilseeds will dominate human dietaries to even greater extents in all world areas as the years pass. The wide diversities of need, local preference, tradition, religious sanction, regional availability, and still other factors pose formidable challenges to agriculturists, food scientists, food processors, and governments. With India as a current example, the many factors which must be considered with respect to fortification of wheat and rice being shipped to that country are discussed with respect to costs and various feasibility factors.

### EXPANDED CONVENIENCE PRODUCTS

*Arthur I. Morgan, Jr. and Robert P. Graham*

Cereal Science Today 12(11): 473-476, Nov. 1967.

The authors describe several recently developed products and processes, including lye-peeled, heat-expanded grains (wheat, barley, rice, soybeans), microwave-dried apples, potatoes, rice, beans, candies, fruit purees, and powders made by drying of foams (citrus, tomato, and others). Expanded foams have the advantage of ease of hydration.

### MICROWAVES FOR QUICK-COOKING RICE

*C. C. Huxsoll and A. I. Morgan, Jr.*

Cereal Science Today 13(5): 203-206, May 1968.

Microwave energy offers some advantage over more conventional energy sources for processing quick-cooking rice because of (1) its volume-heating effect, which cooks the rice with a minimum amount of clumping, and (2) a very rapid heating effect, which can impart a porous structure to dried precooked grains. Because of the cost per unit of energy in the form of microwaves, effort should be made to limit the amount of microwave energy consumed per unit of throughput. In designing practical processing systems, the microwave applicator should be tailored to the process.

## COMPOSITION and QUALITY

### STEAM BLANCHING OF FRESH ROUGH RICE CURBS SPOILAGE BY FATTY ACIDS

*R. L. Roberts, G. R. Van Atta, I. R. Hunter, D. F. Houston, E. B. Kester, and H. S. Olcott*

Food Indus. 21(8): 1041, Aug. 1949.

Short steam treatments of fresh rough rice, as little as 1 minute, inhibit lipase, result in relatively stable bran and brown rice, allow recovery of high-grade edible oil, and do not damage milling quality.

### DEVELOPMENT OF FREE FATTY ACIDS DURING STORAGE OF BROWN (HUSKED) RICE

*I. R. Hunter, D. F. Houston, and E. B. Kester*

Cereal Chem. 28(3): 332-339, May 1951.

Development of free fatty acid in commercially dehulled Caloro brown rice stored 22 weeks at moisture levels of 3.9, 6.6, 9.5, 11.8, and 14.1 percent (wet basis) and at temperatures of 0° to 2°, 25°, and 35°C. (32° to 35.5°, 77° and 95°F.) increased with the moisture content and temperature of storage. An increase in free fatty acids of approximately 1 percent per month resulted at 0°C. (32°F.) in rice containing 14.1 percent moisture, and at 25°C. (77°F.) in rice with 6.6 percent moisture. At 25°C. (77°F.), the initial rates of acid formation were reduced about four-fold by lowering the moisture content from 14.1 to 9.5 percent and sixteen-fold by drying to 3.8 percent. Two portions of a separate lot of Caloro brown rice, prepared in the laboratory from paddy rice stored 7 weeks at 1.5°C. (35°F.) with 21.9 percent moisture, were dried to 13.9 percent and 15.2 percent moisture and stored at 25°C. (77°F.). Development of free fatty acids was generally similar to that of the first lot. Observed differences indicate possible variations in a single variety of rice under differing cultural, storage, and milling conditions. Other varieties would be expected to give similar results.

### EFFECT OF STEAMING FRESH PADDY RICE ON THE DEVELOPMENT OF FREE FATTY ACIDS DURING STORAGE OF BROWN RICE

*D. F. Houston, I. R. Hunter, and E. B. Kester*

Cereal Chem. 28(5): 394-399, Sept. 1951.

The rates of free fatty acid development at 25°C. have been determined in brown rice prepared from portions of freshly harvested moist paddy rice (21.9% $H_2O$, wet basis) which had been steamed various lengths of time at 88°, 93.5°, and 100°C. before drying. The free fatty acids in the oil of the first storage series (13.4 to 13.9% $H_2O$), steamed 5 and 15 minutes at the three temperatures, increased by 2.1 to 2.9 percent during 140 days' storage compared with 10.0 percent for the unsteamed control (13.9 percent $H_2O$). The second series (12.9 to 13.4 percent $H_2O$), steamed 1, 2, 3, and 4 minutes at 100°C. increased by 1.7 to 2.1 percent in the same time and 5.7 to 5.8 percent in 285 days. The control (15.2 percent $H_2O$) showed an increase of 14.3 percent at 140 days and 13.8 percent at 285 days. Enzyme inactivation appeared essentially complete in all steamed samples. The fatty acid development in the brown rice from steamed paddy followed an autocatalytic curve that can be expressed by $dF/dt = k(F)\,(100-F)$, where $F$ is the percentage of free fatty acid in the oil, $(100-F)$ the percentage of unhydrolyzed oil, and $t$ the time in days. Additional effects of the steaming treatment are: slight improvement in milling quality, complete loss of viability, and more rapid development of rancidity, as evidenced by peroxide numbers after 140 days' storage of 39.8 to 80.0 for the oil of samples in series No. 1, compared with 21.9 for the control.

### HYGROSCOPIC EQUILIBRIUM OF BROWN RICE

*David F. Houston*

Cereal Chem. 29(1): 71-76, Jan. 1952.

Equilibrium moisture contents of Caloro brown rice at 25°C. (77°F.) have been determined for atmospheric relative humidities of 11 to 93 percent, together with the rates of approach to equilibrium. Moisture contents at 10 percent R.H. increments, beginning at 10 percent, are: 6.2, 8.0, 9.5, 10.9, 12.3, 13.5, 14.8, 16.2, and 19.1 percent. The extent of hysteresis effects in sorption of moisture by the brown rice is indicated by the fact that rice brought to equilibrium at 40 to 65 percent relative humidity from a dry condition attains a moisture content 0.7 to 1.0 percent lower than that resulting from direct drying of moist rice to the same relative humidity.

### EFFECT OF BRAN DAMAGE ON DEVELOPMENT OF FREE FATTY ACIDS DURING STORAGE OF BROWN RICE

*D. F. Houston, Elizabeth A. McComb, and E. B. Kester*

Rice Journal 55(2): 17-18, Feb. 1952.

Brown rice prepared with rubber shelling rolls has an almost undamaged bran layer, as compared to brown rice dehulled with the usual shelling stones. The effect of this difference in bran damage on the development of free fatty acid was studied during storage of rubber-shelled Caloro rice (control) and two samples from the same lot damaged by treatment with shelling stones. The fatty acid in the total oil of the control sample (with 12 percent readily extractable oil) increased 4.4 percent in 8 months, while that of the damaged samples (50 and 62 percent extractable oil) increased 12.2 and 14.7 percent--three times that of the control. Moreover, the rubber-shelled brown rice retained its fresh odor and attractive appearance, while the damaged samples soured and their surfaces became fuzzy and whitened. Prevention of bran damage is clearly shown to increase the storage qualities of brown rice.

### RAPID METHOD FOR MOISTURE IN FRUITS AND VEGETABLES BY OXIDATION WITH DICHROMATE. II. PINEAPPLE-RICE PUDDING, RICE, PRUNES, AND CORN

*Yoshio Tomimatsu and Herbert F. Launer*

Food Technol. 6(8): 281-285, 1952.
The rapid, simple method for moisture determination in fruits and vegetables, based upon oxidation with potassium dichromate solution, has been applied to pineapple-rice pudding, rice, prunes, and fresh frozen corn. Data are presented on precision and accuracy.

### A NOTE ON THE SUGARS IN RICE

*K. T. Williams and Arthur Bevenue*
Cereal Chem. 30(3): 267-269, Nov. 1953.
In long-grain, short-grain and waxy U.S. rices total sugars were almost as much (0.66-1.06 percent)in milled parboiled as in brown rice (0.83-1.40 percent) but were reduced in white milled rice (0.37-0.51 percent). Reducing sugars, amounting to only 0.07-0.19 percent were almost entirely glucose with a trace of fructose. Nonreducing sugars were practically all sucrose with a trace of raffinose.

### EFFECT OF PROCESSING CONDITIONS ON THE EXPANDED VOLUME, COLOR, AND SOLUBLE STARCH OF PARBOILED RICE

*R. L. Roberts, A. L. Potter, E. B. Kester, and K. K. Keneaster*
Cereal Chem. 31(2): 121-129, March 1954.
Several samples of parboiled rice were prepared under widely varied processing conditions. Measurements of expanded volume, color, and soluble starch were made and compared with steeping and steaming treatments. Steaming temperature exhibited the greatest influence on all of these factors, while steeping conditions and steaming time showed minor effects.

### HYGROSCOPIC EQUILIBRIA OF WHOLE-GRAIN EDIBLE FORMS OF RICE

*D. F. Houston and E. B. Kester*
Food Technol. 8(6): 302-304, June 1954.
Equilibrium moisture values have been determined for parboiled and quick-cooking rices at 77°F. and parboiled rice at 100°F. at relative humidities of 11 to 93 percent. Hysteresis effects were found to be greater on quick-cooking and parboiled rices (processed with moist heat) than on raw white and brown rices.

### CEREAL STORAGE EFFECTS. DETERIORATIVE CHANGES IN THE OIL OF STORED PARBOILED RICE

*David F. Houston, Irving R. Hunter, Elizabeth A. McComb, and Ernest B. Kester*
J. Agr. Food Chem. 2(23): 1185-1190, Nov. 10, 1954.
Rancidification and nonenzymatic changes in the oil of parboiled rice stored at 77°, 100° and 140°F. in the dark in open and closed containers were measured as peroxides, monocarbonyl compounds and free acids. In open containers peroxides and monocarbonyls rose markedly after an induction period, then decreased to low values. Free acids rose in a similar manner, but remained high. Changes found at 1 year at 77°F. occurred at about 1 month at 100°F. and 1 week at 140°F. In closed containers peroxide and monocarbonyls showed similar behavior after longer induction periods. No rise occurred at 140°F. Free acidity increased linearly. Light accelerated rancidity at 77°F.

### STARCHY CEREAL THICKENING AGENTS FOR CANNED FOOD PRODUCTS

*J. G. Davis, J. H. Anderson, and H. L. Hanson*
Food Technol. 9(1): 13-17, Jan. 1955.
For utility as thickening agents in canned foods, pastes made from wheat flour, cornstarch, waxy-rice flour, waxy cornstarch, waxy-corn flour, and waxy-sorghum flour have been investigated. Use of the waxy-cereal thickenings and mixtures of waxy and nonwaxy were found to contribute greater storage stability to the foods than use of wheat flour or cornstarch alone. Waxy-rice flour was most effective in reduction of "setting up" and liquid separation of the pastes.

### ADSORPTION-DIALYSIS, AN EXTRACTION TECHNIQUE AND ITS USE IN RECOVERY OF AMINO ACIDS

*I. R. Hunter, D. F. Houston, and E. B. Kester*
Analyt. Chem. 27(6): 965-968, June 1955.
An extraction procedure useful for recovering amino compounds from biological materials is described, which involves the combined use of adsorption and dialysis.

### CEREAL COMPONENTS--FREE AMINO ACIDS OF FRESH AND AGED PARBOILED RICE

*I. R. Hunter, R. E. Ferrel, and D. F. Houston*
J. Agr. and Food Chem. 4(10): 874-875, Oct. 1956.
Eighteen free amino acids were identified by filter-paper chromatography of adsorption-dialysis extracts of fresh and oven-aged parboiled rice.

### CEREAL STORAGE EFFECTS--STORAGE CHANGES IN PARBOILED RICE

*D. F. Houston, I. R. Hunter, and E. B. Kester*
J. Agr. Food Chem. 4(11): 964-968, Nov. 1956.
Color changes in Pearl and Century Patna parboiled rice at room temperature were negligible but at 100° and 140°F. they appeared within 3 to 4 months. Accelerated tests at 140°F. on rice parboiled by varied methods revealed that varietal differences had only a minor effect but differences in processing method changed the keeping quality of a single variety. Sulfite disappeared during storage; it inhibited browning but did not delay rancidification.

### RICE ANALYSIS--HEMICELLULOSE COMPONENTS OF RICE

*A. Bevenue and K. T. Williams*
J. Agr. Food Chem. 4(12): 1014-1017, Dec. 1956.
The hemicelluloses of rice bran, rice polish, and polished rice are composed of small amounts of uronic acid, galactose and mannose, with arabinose and xylose occurring as the major sugars in the ratio of 1:1.

### TIME-TEMPERATURE TOLERANCE OF FROZEN FOODS. V. TEXTURE STABILITY OF THICKENED PRECOOKED FROZEN FOODS AS INFLUENCED BY COMPOSITION AND STORAGE CONDITIONS

*H. L. Hanson, L. R. Fletcher, and A. A. Campbell*

Food Technol. 11(6): 339-343, June 1957.
Temperature fluctuating between -10° and 10°F. was found to be considerably more detrimental than constant 0°F. to texture stability of foods such as white sauce and custard pudding. Texture stability in thickened desserts containing waxy rice flour, egg yolk, milk, and sugar was influenced by variations in proportions of these 4 basic ingredients. Citrus pectin and gelatin at 1 percent in white sauce and custard pudding thickened with waxy-rice flour prevented curdling and liquid separation for several months at 10°F.

### TIME-TEMPERATURE TOLERANCE OF FROZEN FOODS. XII. TURKEY DINNERS AND TURKEY PIES

*H. L. Hanson and L. R. Fletcher*

Food Technol. 12(1): 40-43, Jan. 1958.
Turkey dinners and turkey pies, both laboratory and commercial preparations, were evaluated for flavor and other changes after storage at temperatures ranging from -30° to 20°F. These products are 3 to 6 times as stable at 10° as at 20°F. Under conditions used, antioxidant addition did not cause sufficient improvement in flavor stability of the meat to warrant its inclusion in dinners stored for a year at 0°F. or 6 months at 10°F. Temperatures fluctuating from 0° to 20°F. and from -10° to 10°F. did not cause flavor changes differing from those held at the mean temperatures of 10° and 0°F.

### ESTROGEN-LIKE ACTIVITY IN VEGETABLE OILS AND MILL BYPRODUCTS

*A. N. Booth, E. M. Bickoff, and G. O. Kohler*

Science 131(3416): 1807-1808, June 17, 1960.
A report on findings that a number of the commonly used vegetable oils are capable of producing estrogen-like responses in mice.

### SOME FACTORS INFLUENCING RICE HOT-PASTE VISCOSITY

*Ernest B. Kester*

Proc. Rice Tech. Working Group, June 29 to July 1, 1960, Lafayette, La., p. 19, Feb. 1961.
In a study of 13 domestic varieties of rice, it was found that culture, stage of maturity, amylose content and storage history contribute to hot-paste viscosity behavior. Viscosity variations are probably due to changes in molecular structure of amylose, amylopectin, or protein constituents in various environments. Enzymatic action may be influential.

### PARBOILING CHARACTERISTICS OF CALIFORNIA MEDIUM-GRAIN RICE

*D. K. Mecham, E. B. Kester, and J. W. Pence*

Food Technol. 15(11): 475-479, Nov. 1961.
Optimal soaking and steam-cooking conditions have been determined for the Calrose variety of rice.

### DEMONSTRATION OF HUMAN REAGINS TO FOODS, CAT DANDER, AN INSECT, RAGWEED AND GRASS POLLENS

*L. L. Layton, Elaine Yamanaka and Charles W. Denko*

J. Allergy 33(3): 271-275, May-June 1962.
Cooperative research, Ohio State University Hospital, Columbus, Ohio.
Serum from patients with food allergy due to cereals and peanuts as well as from patients with respiratory allergy due to cat dander and to ragweed and grass pollens sensitized the skin of the cynomolgus monkey *Macaca irus*. This was demonstrated by challenge with an allergenic extract which elicited passive cutaneous anaphylaxis with extravasation of intravenously injected Evans blue dye in the sites sensitized to the particular antigen. Testing of human sera in monkeys appears to give results that correlate well with cutaneous tests in human beings and appears suitable for use as a research tool.

### RICE PROTEINS--II

*D. F. Houston*

Rice Journal 65(12): 25, Nov. 1962; also in U.S. Dept. Agr. ARS-74-24, p. 7.
A summary of work on rice proteins at Western Regional Research Laboratory, presented at the Second Conference on Rice Utilization, May 18-19, 1961, Albany, California.

### INFLUENCE OF MATURITY ON PROPERTIES OF WESTERN RICES

*E. B. Kester, H. C. Lukens, R. E. Ferrel, A. Mohammad, and D. C. Finfrock*

Cereal Chem. 40(4): 323-336, July 1963.
(Cooperation research with Calif. Rice Experiment Station, Biggs)
Chemical constituents and physical properties of rice change as the rice matures. Measurements made on Calrose, Caloro, and Colusa varieties revealed that maximum yields of head rice and minimum hot paste viscosity and water absorption occurred early in the maturation process, and then the trends reversed. Amylolytic activity was highest at the point of trend reversal. Reflectance properties shifted direction simultaneously. Rice harvested at mid-season showed the most yellow color, the lowest lightness and whiteness values, and the least chalkiness. Chlorophyll was detectable in the mid-harvest season, but disappeared several days later when translucency, as measured by light transmission, reached near maximum values. The late stages of maturity were characterized by loss of yellow color, increasing lightness and whiteness values, but little change in chalkiness.

### RICE QUALITY MEASUREMENT. ORGANIC ACIDS OF RICE AND SOME OTHER CEREAL SEEDS

*David F. Houston, Vilma H. Garrett, Beverly Hill, and E. B. Kester*

J. Agr. Food Chem. 11(6): 512-517, Nov.-Dec. 1963.

Citric is the predominant acid, followed by oxalic, malic, and succinic acid. The fingerprint patterns of the acids for 7 varieties of rough rice are similar, though there are quantitative varietal differences. Long-grain rices show the lowest total acid content and lowest percentage as organic acid. Among the milling fractions, bran plus germ show much the greatest acid concentration and milled rice, the lowest. Acetic acid is present mostly in the hulls, and aromatic acids are concentrated in the bran and hulls. The total acids of milled rice decrease as maturity is approached and increase on storage under adverse conditions. Rice had the lowest acid content of the cereals tested. The fingerprint pattern of rice organic acids is most like that of corn and least like that of barley, oats, and wheat.

### OCCURRENCE OF POLYAMINES IN THE GERMS OF CEREALS

*G. Moruzzi and C. M. Caldarera*

Arch. Biochem. Biophys. 105(1): 209-210, April 1964.

(Public Law 480 grant, Universita di Bologna, Italy)

Data are given for the amounts of certain polyamines including cadaverine, putrescine, and spermidine occurring in wheat, rice, barley, oats, corn, and sorghum.

### HIGH-SULFUR SEED PROTEINS

*David F. Houston, Ali Mohammad, and Norma E. Alfonso Hernandez*

Cereal Chem. 41(5): 427-428, Sept. 1964.

This is a preliminary report of data comparing high-sulfur protein in rice with high-sulfur seed proteins in wheat, oats, barley, and peanuts.

### QUALITY EVALUATION STUDIES OF FOREIGN AND DOMESTIC RICES

*J. E. Simpson, C. R. Adair, G. O. Kohler, E. H. Dawson, H. J. Deobald, E. B. Kester, J. T. Hogan, O. M. Batcher, and J. V. Halick*

U.S. Dept. Agr. Tech. Bull. 1331, 186 pp., illus., October 1965.

(Cooperating agencies, were Foreign Agr. Serv., Agr. Marketing Serv., and Agr. Res. Serv.).

This bulletin describes methods and procedures used in making physical measurements, studying thermal and chemical reactions, making chemical determinations, and evaluating palatability characteristics of rice samples gathered from 33 foreign countries. Samples of U. S. rices (long-, medium-, and short-grain) were included for comparison. The information will aid research agencies in developing new strains and varieties of rice especially adapted to the requirements of overseas markets, thus assisting in directing rice of the most desired types into each significant marketing area. Voluminous technical data (27 tables)--both objective and subjective measurements--were subjected to detailed statistical studies in an effort to establish possible correlations between the various factors. The studies revealed certain significant correlations, indicated interesting trends, and pointed out the need for further research to better establish certain relationships and to simplify technical procedures for fully characterizing rice cooking and processing qualities. A bibliography of 46 items is included.

### COMPARISON IMMUNOLOGIQUE DES $\alpha$-AMYLASES EXTRAITES DE CEREALES (IMMUNOLOGIC COMPARISON OF $\alpha$-AMYLASES EXTRACTED FROM CEREALS)

*J. Daussant and P. Grabar*

Annales de l'Institut Pasteur Tome 110: 79-83, March 1966.

(Public Law 480 grant, Pasteur Institute, Paris, France.)

Proteins in different cereals possessing the same enzymatic activity on one hand and a common physiological characteristic on the other hand may or may not share the same antigenic properties. Identity reactions have been observed between $\alpha$-amylases extracted from germinated seeds of barley, wheat, and rye; however these amylases crossreacted with those extracted from germinated seeds of oats and maize. $\alpha$-Amylases extracted from germinated seeds of rice do not react with an immune serum containing antibodies against $\alpha$-amylase of barley malt, under the conditions employed.

### COLORIMETRIC DETERMINATION OF CALCIUM IN RICE AND WHEAT

*Earl F. Potter and Marion C. Long*

J. Assoc. Off. Analyt. Chem. 49(5): 905-906, Oct. 1966.

Micro amounts of calcium in cereals have been determined colorimetrically with glyoxal-bis (2-hydroxyanil) reagent. Interfering heavy metals are removed by extraction with sodium diethyldithiocarbamate.

### SUBSTRATE SPECIFICITY OF THE GRANULE-BOUND AND CHLOROPLASTIC STARCH SYNTHETASE

*Yoshimasa Tanaka and Takashi Akazawa*

Plant & Cell Physiol. 9(2): 405-410, June 1968.

(P. L. 480 grant, Nagoya Univ., Nagoya, Japan.)

Comparisons were made of the specificities of the starch synthetases in rice and spinach by use of starch-bound and free enzyme preparations. Specificity with regard to the purine moiety of the substrate appears to be mainly organ-specific, i.e., each plant organ has a characteristic enzyme, and this specificity is related to the metabolic pattern of the individual plant organ.

### ENZYMIC MECHANISM OF STARCH SYNTHESIS IN SWEET POTATO ROOTS. I. REQUIREMENT OF POTASSIUM IONS FOR STARCH SYNTHETASE

*T. Murata and T. Akazawa*

Arch. Biochem. Biophys. 126(3): 873-879, Sept. 1968.
(P. L. 480 grant, Nagoya University, Nagoya, Japan.)

From the results of kinetic experiments with sweet potato root enzyme, it was found that the addition of 0.1 M $K^+$ increases enzyme activity about 7-fold, and $K_A$ value was determined to be 1.3 x $10^{-2}$M. The level of $K^+$ giving the maximum starch synthetase activity was about 0.05-0.1 M, roughly equivalent to the cellular concentration of $K^+$ in sweet potato roots. However, both $K_m$ adenosine diphosphate glucose (ADPG) and $K_i$ (ADP) values were not affected by the addition of $K^+$ to the reaction system. Pretreatment of the sweet potato enzyme with $K^+$ caused an appreciable protective effect against the heat-inactivation of enzyme, while nearly complete loss of enzyme activity occurred without $K^+$ treatment. Some physiological implications have been made concerning the dynamic role of $K^+$ in regulating the starch synthesizing reaction in sweet potato roots.

### RADIAL DISTRIBUTION OF PROTEIN BY SOLUBILITY CLASSES IN THE MILLED RICE KERNEL

*David F. Houston, Tetsuya Iwasaki, Ali Mohammad, and Lora Chen*

J. Agr. Food Chem. 16(5): 720-724, Sept.-Oct. 1968.

Radial distribution of the four solubility classes of protein was determined for eight varieties of milled rice. Five consecutive layers of the kernel, totaling about 10 percent by weight, were removed by abrasive milling. Original and residual kernels and all flours were percolated successively with water, 5 percent sodium chloride and 60 percent ethanol to remove albumins, globulins and prolamins; glutelins were calculated by difference. Albumin and globulin were concentrated in proteins at the surface of all rices; concentrations decreased toward the kernel center. Globulin generally was somewhat less concentrated than albumin in the outer kernel layers and had less steep gradients toward the center. Globulin and albumin gradients differed independently among varieties. The limiting amino acid, lysine, occurred in 12 percent greater concentration in the protein of the outer layer of Calrose rice than in the protein of the total kernel.

### ENZYMIC MECHANISM OF STARCH BREAKDOWN IN GERMINATING RICE SEEDS. I. AN ANALYTICAL STUDY

*Takao Murata, T. Akazawa, and Shikiko Fukuchi*

Plant Physiol. 43(12): 1899-1905, Dec. 1968.
(P. L. 480 grant, Nagoya University, Nagoya, Japan.)

Rapid breakdown of rice endosperm starch began after about 4 days of germination, with a marked increase in production of glucose and malto-oligosaccharides, especially maltotriose. Alpha-amylase activity paralleled the pattern of starch breakdown; phosphorylase activity was much weaker. Sucrose content decreased during the first 4 days, then gradually increased during later germination stages. No sucrose synthetase activity was detected in the endosperm. The authors propose the predominant formation of glucose from starch reserves in the endosperm by alpha-amylase and accompanying hydrolytic enzymes and the eventual mobilization of this sugar to growing tissues.

### ADSORPTION OF SOLUBLE STARCH SYNTHETASE FROM SPINACH LEAF WITH AMYLOSE

*Yoshimasa Tanaka and Takashi Akazawa*

J. Japanese Soc. Starch Sci. 17(1): 229-236 1969.
(P. L. 480 grant, School of Agriculture, Nagoya Univ., Nagoya, Japan.)

It was found that a partially purified preparation of ADP-glucose-$\alpha$-(1→4) glucan glucosyl transferase (starch synthetase) from spinach leaves is bound specifically with the amylose molecule. The adsorption of starch synthetase with starch granules prepared from nonglutinous rice seeds was quite strong, while the binding reaction of starch granules from glutinous rice seeds was less. The specific adsorption of the soluble enzyme with amylose was studied under various experimental conditions. The reaction was weakest at an acid pH (around 5.0) and maximal near neutral pH. At temperatures higher than 25°C. fewer enzyme molecules were bound to amylose. By determining time effect of enzyme adsorption to the amylose molecule, it was found that strength of binding increased with time. However, the lack of change of substrate specificity of the chloroplastic soluble starch synthetase after binding suggests that starch synthetase of different plant origins may exhibit organ specific substrate utilization.

### ENZYMIC MECHANISM OF STARCH SYNTHESIS IN SWEET POTATO ROOTS. II. ENHANCEMENT OF THE STARCH SYNTHETASE ACTIVITY BY MALTOOLIGOSACCHARIDES

*T. Murata and T. Akazawa*

Arch. Biochem. Biophys. 130(1-2): 604-609, March 1969.
(P. L. 480 grant, Nagoya University, Nagoya, Japan.)

The stimulatory effect of oligosaccharides on the incorporation of $^{14}$C-glucose into starch granules (starch synthesis) was found to be novel and not due to the mere adherence of the radioactive oligosaccharides formed by the transglucosylation reaction (oligosaccharide synthesis). The stimulatory effect of $K^+$ and oligosaccharide on the enzyme reaction proved to be additive if adenosine diphosphate glucose (ADPG) was used as the glucose donor. However, there was an optimal level of $K^+$ for the enzymic transglucosylation reaction if uridine diphosphate glucose (UDPG) was used as the glucose donor. At high levels of $K^+$, oligosaccharide did not exhibit any stimulatory effect. Over the entire range of added $K^+$, the rate of oligosaccharide synthesis appeared to exceed that of the starch-synthesizing reaction with both ADPG and UDPG as glucose donors. The mutual interaction of glucose with $K^+$ and with maltooligosaccharide in the starch synthesizing reaction was studied.

### ENZYMIC MECHANISM OF STARCH BREAKDOWN IN GERMINATING RICE SEEDS. II. SCUTELLUM AS THE SITE OF SUCROSE SYNTHESIS

*Takeo Nomura, Yasuhiro Kono, and T. Akazawa*
Plant Physiol. 44(5): 765-769, May 1969.
(P. L. 480 grant, Dept. of Agronomy, Nagoya University, Nagoya, Japan.)

In a close parallel to the developmental pattern of $\alpha$-amylase activity, a rapid increase of maltase activity occurred in the endosperm tissue of germinating rice seeds after about 4 days of seed imbibition. The overall pattern of the two hydrolytic enzyme activities strongly suggests that amylolytic breakdown is the major metabolic route of starch utilization in the germinating rice seeds. Results of the chemical analyses of sugar constituents as well as the measurements of sucrose synthetase activity show that the scutellum is the site of sucrose synthesis in the germinating rice seeds. It is thus supported that glucose derived from the reserve starch in endosperm is transported to the scutellum, where it is converted to sucrose. Sucrose is further mobilized to the growing tissues, shoots, and roots.

### STIMULATIVE EFFECT OF POTASSIUM ION ON STARCH SYNTHETASE OF DIFFERENT PLANT ORIGINS

*Takao Murata and Takashi Akazawa*
Plant & Cell Physiol. 10(2): 457-460, June 1969.
(P. L. 480 grant, School of Agriculture, Nagoya University, Nagoya, Japan.)

The stimulative effect of $K^+$ on the activity of granule-bound starch synthetase was uniformly observed in the enzyme preparations obtained from the root, leaf, and stem of sweet potato plants. The stimulation of $K^+$ was most marked with the sweet potato enzyme; the broad bean enzyme was also appreciably stimulated. The $K^+$ effect was very small in the enzyme from rice, barley, and taro plants.

### AMINO ACID COMPOSITION OF RICE AND RICE BY-PRODUCTS

*D. F. Houston, Marian E. Allis, and G. O. Kohler*
Cereal Chem. 46(5): 527-537, Sept. 1969.

Data are presented from chromatographic analyses of amino acid contents of seven U.S.-milled rices and such milling by-products as bran, polish, bran-plus-polish, millfeed, and hulls. Values for serine, threonine, valine, and isoleucine were corrected by factors based on earlier work. Cystine and methionine were determined after performic acid oxidation.

Composition of each milling fraction was very similar for all varieties and process differences. However, appreciable differences occurred between different milling fractions. Ratios of individual to total essential amino acids and of total essential amino acids to total amino acids in milling fractions are compared with each other and with values for egg proteins as estimates of nutritional quality. Comparisons of amino acid composition found for milled rice and bran with the rather variable data reported in the current literature show generally higher present values for sulfur amino acids and others requiring special consideration for analysis.

### PURIFICATION AND PARTIAL CHARACTERIZATION OF A MAJOR GLOBULIN FROM RICE ENDOSPERM

*David F. Houston and Ali Mohammad*
Cereal Chem. 47(1): 5-12, Jan. 1970.

Albumins and globulins were extracted from rice flour with 5% sodium chloride solution. A major globulin component was purified by ammonium sulfate precipitation, repeated isoelectric precipitations, and gel-filtration chromatography. Progress was monitored by starch-gel electrophoresis. The purified globulin component migrates as a single compound in free-film and starch-gel electrophoresis, in column chromatography, and in ultracentrifugation. In the presence of urea it apparently dissociates into two portions which recombine when urea is removed. It shows no amylase activity, contains 18.1% nitrogen, has high glutamic acid and arginine content, moderately high serine, tyrosine, cystine, and methionine content, about 1% tryptophan, and essentially no lysine or histidine. Molecular weight estimated by Sephadex chromatography is about 25,500, and calculated from amino-acid content is 25,330. It has a sedimentation constant of 1.6S and a calculated specific volume of 0.706.

### ENZYMIC MECHANISM OF STARCH BREAKDOWN IN GERMINATING RICE SEEDS III. $\alpha$-Amylase Isozymes

*Yoshimasa Tanaka, Tomoko Ito, and Takashi Akazawa*
Plant Physiol. 46: 650-654, 1970
(P. L. 480 grant, Nagoya University, School of Agriculture, Chikusa, Nagoya, Japan)

The formation of amylase isozymes in germinating rice (Oryza sativa) seeds was studied by isoelectric focusing on polyacrylamide gel disc electrophoresis. Time sequence comparisons of the amylase zymogram were made between extracts from gibberellic acid-treated embryoless and embryo-attached half-endosperm of rice seeds. In both cases, four major and nine to ten minor isozyme bands were detectable at the maximal stage of the enzyme induction. However, in the embryo-attached half-seeds, bands started to diminish after the fifth day of incubation, in agreement with the results of time sequence analyses of enzyme activities. Nearly identical patterns of amylase isozyme bands on a polyacrylamide gel disc electrophoresis in combination with isoelectric focusing indicate the intrinsic role of gibberellic acid in the starch breakdown in germinating rice seeds. Newly synthesized enzymes were tentatively judged to be $\alpha$-amylases, based on experimental results concerning the lability of the preparation on a prolonged treatment at pH 3.3 and the stability on heat treatment for 15 minutes at 70°C.

### COMPARISON OF AERATION, TURNING, AND FLAT STORAGE AS MEANS OF MAINTAINING QUALITY OF WESTERN-GROWN RICE. A PRELIMINARY REPORT

*E. B. Kester, K. W. Taylor, and D. C. Finfrock*
Rice Journal 58(4): 12, 14, 16, April 1955. (Cooperative research with University of California).
Bin-scale storage experiments of Western-grown rough rice during 1953-54 indicate that aeration or turning may be more important factors in maintaining quality than moisture content. Rice stored at moisture levels of 11.0, 13.5, and 15.6 percent when aerated or turned retained U.S. No. 1 grade for 9 months to August 1, whereas rice of the same moisture contents in flat storage deteriorated to U.S. No. 2 in 7 months to June 1.

### DRYING CHARACTERISTICS OF WESTERN RICE--COLUSA 1600 VARIETY

*J. H. Thompson, A. H. Brown, W. D. Ramage, R. L. Roberts, and E. B. Kester*
Rice Journal 58(11): 14, 16, 18-19, Oct. 1955.
Develops a basic pattern for drying Colusa 1600 rice, relating the drying air temperature (75-140°F.) and number of drying passes (1-5) to head yield and drying time in diagram form to assist the dryer operator in determining the trends of effects of changing operating variables regardless of the type of dryer. Results of changes in air humidities, air velocities, and moisture redistribution during tempering are given together with a discussion of dryer operator problems in California.

### DRYING CHARACTERISTICS OF WESTERN RICE--CALORO VARIETY. I. EQUAL MOISTURE REMOVAL AND CONSTANT DRYING AIR TEMPERATURES IN ALL PASSES

*T. Wasserman, A. H. Brown, D. F. Houston, and R. E. Ferrel*
Rice Journal 59(3): 12-16, March 1956.
The type of relationship between drying-air temperature, total drying time, terminal head yield, and number of passes previously reported for Colusa 1600 rice also holds for Caloro rice.

### DRYING CHARACTERISTICS OF WESTERN RICE--CALORO VARIETY. II. VARYING DRYING AIR TEMPERATURE AND AMOUNT OF MOISTURE REMOVED IN EACH PASS

*T. Wasserman, A. H. Brown, D. F. Houston, and R. E. Ferrel*
Rice Journal 59(4): 41-45, April 1956.
A report on head-rice yields as affected by drying-air temperature and number of passes. Removal of more moisture in the first pass and less in the last resulted in higher head yield, with little lengthening of time, as compared with removal of the same amount in each pass. Decreasing air temperatures with successive passes improved yield but lengthened time substantially.

### REEL DRYING OF ROUGH RICE AT HIGH TEMPERATURES

*T. Wasserman, J. H. Thompson, E. B. Kester, and R. E. Ferrel*
Rice Journal 59(11) 13-16, Oct. 1956.
As compared with continuous drying in a bin with air at 70°F., reel drying resulted in only slightly lower yields of head rice of two of the western varieties tested. A comparison of reel with static bin drying at 150°F. in 5.5-inch beds showed that reel drying results in superior milling yields and shorter drying times.

### STORAGE BEHAVIOR OF RICE IN EXPERIMENTAL BINS, 1954-55

*E. B. Kester, D. F. Houston, R. E. Ferrel, I. R. Hunter, and D. C. Finfrock*
Rice Journal 59(9): 24, 26-27, Aug. 1956. (Cooperative Research with University of California).
Quality tests on the 1954 crop of Caloro rice stored in 1,000-bushel bins at Biggs Rice Experiment Station are reported. The importance of reducing dockage in rough rice to a low level and the advantages of aeration were demonstrated by this year's and the previous year's results.

### CHANGES IN ROUGH RICE OF DIFFERENT MOISTURE CONTENTS DURING STORAGE AT CONTROLLED TEMPERATURES

*D. F. Houston, R. P. Straka, I. R. Hunter, R. L. Roberts, and E. B. Kester*
Cereal Chem. 34(6): 444-456, Nov. 1957.
Caloro rough rice samples with varied moisture content were stored for 7 months at 70° and 90°F. and tested monthly for moisture, odor, viability, milling yields, free acidity, monocarbonyl compounds, total and reducing sugars, and counts of molds, yeasts, actinomycetes, aerobic, and anaerobic bacteria. Changes in characteristics, reported in detail, occurred more quickly and more extensively as moisture content or temperature was increased.

### COMMERCIAL DRYING OF WESTERN RICE

*T. Wasserman, R. E. Ferrel, A. H. Brown, and G. S. Smith*
Cereal Science Today 2(9): 251-254, Nov. 1957.
Describes procedures used in commercial drying of western-grown rice, outlines laboratory-scale and plant-scale studies on rice drying. The studies provide data needed by the commercial dryer in adjusting his practices to meet varying situations.

### IMPROVEMENTS IN COMMERCIAL DRYING OF WESTERN RICE. I. MIXING TYPE DRYER--LOUISIANA STATE UNIVERSITY DESIGN

*T. Wasserman, R. E. Ferrel, V. F. Kaufman, G. S. Smith, E. B. Kester, and J. G. Leathers*

Rice Journal 61(4): 30-32, 34-36, 38, April 1958.
Plant capacity, head yield, and total yield were increased and costs were decreased. Tests and instructions were developed to enable a plant operator to find the most efficient drying conditions for his plant.

### IMPROVEMENTS IN COMMERCIAL DRYING OF WESTERN RICE. II. NONMIXING COLUMNAR-TYPE DRYER

*T. Wasserman, R. E. Ferrel, V. F. Kaufman, G. S. Smith, and E. B. Kester*

Rice Journal 61(7): 9-11, 14, July 1958.
Describes the second of two demonstrations that laboratory results on rice drying can be applied to commercial-scale drying to obtain higher milling yields, increased plant capacity, and lower drying costs. This demonstration was carried out in a plant in West Sacramento, California. Improvements were so obvious that the new methods were immediately adopted by the plant and are now used routinely.

### PRESERVATION OF ROUGH RICE BY COLD STORAGE

*D. F. Houston, R. E. Ferrel, I. R. Hunter, and E. B. Kester*

Cereal Chem. 36(2): 103-107, March 1959.
Caloro rough rice with average moistures of 12.0, 13.1, 14.1, and 15.9% was stored in friction-top cans for 3 years at 34°, 20°, and -20°F. Periodic determinations were made of moisture content, yeast and mold populations, sugars, acidity of the oil, and viability. The data offer evidence that experimental reference material can be suitably held under cold storage, but that for prolonged retention of viability the rice should have less than 13% moisture even under refrigeration.

### PADDY DRIED WITH SHORT TEMPERING PERIODS KEEPS WELL

*D. F. Houston, T. Wasserman, R. E. Ferrel, G. S. Smith, and E. B. Kester*

Rice Journal 62(12): 16, 22-23, Nov. 1959.
Caloro rough rice was dried with 110°F. air in three passes from 20.2 to 13 percent moisture with five different tempering treatments between passes. No appreciable differences were found among the measured characteristics of samples which could be attributed to differences in tempering treatment.

### IMPROVED METHODS FOR DRYING RICE BENEFIT WESTERN RICE INDUSTRY AND CONSUMERS

Research Achievement Sheet 204, U.S. Dept. Agr., processed, Jan. 1961; also in Rice Journal 64(3): 26, 28, March 1961.
Revised drying procedures developed at Western Regional Research Laboratory, Albany, Calif. make it practical to obtain more top-grade rice, permit large increases in plant drying capacity without installation of new dryers, and reduce drying costs. On the basis of prices paid during the past few years, application of the findings to the entire western rice crop could increase returns to the western rice industry by 2 to 3 million dollars annually.

### IMPROVEMENTS IN COMMERCIAL DRYING OF SOUTHERN GROWN RICE. I. ZENITH--A MEDIUM GRAIN VARIETY

*J. Pominski, T. Wasserman, J. J. Spadaro, K. M. Decossas, and A. B. Dore, Jr.*

Rice Journal 64(9): 10, 12-13, 16-17, Aug. 1961.
(Cooperative research with Southern Utilization Research and Development Division)
A new method makes possible improved rice drying operations for many plants in the South processing medium-grain varieties. No additional plant drying equipment is required. This method consists essentially of increasing the feed rate, increasing the number of passes and using higher air-drying temperatures. Increased feed rates usually increase the number of passes, but the total drying time is reduced. The Western Utilization Research and Development Division originally developed this method to determine more efficient drying conditions for California short-grain rice.

### INCREASING LABORATORY HEAD AND TOTAL YIELDS OF ROUGH RICE BY MILLING AT LOW MOISTURE LEVELS. EFFECTS ON BLUEBONNET 50--A LONG-GRAIN VARIETY

*J. Pominski, T. Wasserman, E. F. Schultz, and J. J. Spadaro*

Rice Journal 64(10): 11-15, Sept. 1961.
(Cooperative research with Southern Utilization Research and Development Division)
Over a range of 14 to 10 percent moisture, head yields and total yields increased approximately 3.0 and 0.7 percent, respectively, for each 1 percent decrease in moisture. As the moisture content of rice is lowered, the yield of total milled rice by the test method increases and, correspondingly, the amount of bran and polish (difference between brown and total milled rice) decreases. Since the amount of true rice bran must be constant, the gain in total yield may be due to removal of less polish. Also, fewer fragments of endosperm may be going out with the bran.

### ALTERNATIVE SAMPLE DRYING PROCEDURE FOR USE IN WESTERN RICE DRYERS

*Theodore Wasserman and George S. Smith*

Rice Journal 66(4): 32-33, April 1963.
Samples of moist California Pearl rough rice were dried with 110°F. air in 30-minute cycles in which air and heaters were on 2 minutes and off 28 minutes. The samples dried in the same elapsed time as rice dried continuously with 75°F. air; milling yields were the same. The procedure is useful in hot weather when ambient temperatures are too high for continuous drying without damage.

### COMMERCIAL DRYING OF RICE

*Theodore Wasserman*

California Rancher 17(11): 30, 44, 52, 57, Nov. 1963.

The goal of the commercial dryer is to reduce moisture content of freshly harvested grain to a safe storage level with minimal loss of quality. He is restricted in his choice of operating conditions by permissible operating costs, characteristics of plant equipment, and urgency of drying before spoilage. Drying and attendant duties require knowledge, care, and judgment. The dryer operator must be highly skilled and knowledgeable.

TEMPERING WESTERN RICE

*T. Wasserman, R. E. Ferrel, D. F. Houston, E. Breitwieser, and G. S. Smith*

Rice Journal 67(2): 16-17, 20-22, Feb. 1964.

Data indicates that western short-grain rice can be tempered in a much shorter time than is common in commercial practice without damage to milling quality or increase in drying time. Resulting advantages include increased operating flexibility and prevention of rice spoilage. A summary of current tempering practice and its benefits and limitations are included.

HEATED AIR DRYING OF CALIFORNIA RICE IN COLUMN DRYERS

*Theodore Wasserman, Milton D. Miller, and William G. Golden, Jr.*

Calif. Agr. Ext. Serv. Information Leaflet, July 1965.

(Cooperative research with University of California, Davis, and California State Agricultural Extension Service)

Commercial drying installations differ in dryer type, size, and bed depth, in quantity and velocity of air through the dryer, in tempering and storage space, in capacity of conveying equipment, and in numerous other factors. No single recommendation will fit all installations and situations. It is therefore necessary for each dryer operator to determine the most favorable drying conditions for his plant. This leaflet describes briefly how to obtain optimum drying conditions, summarizes present knowledge of California rice drying and attendant dryer services, and provides guides to a more successful operation.

SOURCES OF VARIABILITY IN LABORATORY MILLING YIELDS OF LONG-GRAIN RICE-DRYING EXPERIMENTS

*E. Fred Schultz, Jr., Joe Pominski, and Theodore Wasserman*

Cereal Chem. 43(3): 284-297, May 1966.

(Cooperative research with Southern Regional Research Laboratory)

Sources and magnitudes of components of variance were determined for head yields of long-grain rice from drying experiments. Since interest centers on the difference between head yields of entering green rice and final-product dried rice, any variability due to days of milling and operator can be eliminated from experimental comparisons by the simple technique of saving early samples from a given drying run and evaluating all samples from such a run on the same day and by the same operator. The variance of head-yield is decreased faster by increasing the replication of sampling of the process stream than by any other form of increased replication.

DRYING AND STORING THE EXPANDING PHILIPPINE RICE CROP

*T. Wasserman*

Rice Journal 73(6): 8-12, 21-22, 28, June 1970.

This paper discusses the massive program of the Philippine government to expand rice production, and the attainment of self-sufficiency in 1968 primarily through introduction of high-yielding varieties. It outlines Philippine practices of rice growing, harvesting, drying, storing and milling, with emphasis on drying and storage and on government participation. A gradual shift occurred from human and animal labor to a mechanized industry and from sacks to bulk in handling rice. Future drying and storage needs for the small farmer, the small trader, and large production groups are discussed. Present dryers and dryer innovations are described.

### METHOD OF MEASUREMENT OF LIPASE ACTIVITY IN RICE BRAN

*D. F. Houston, R. L. Roberts, and E. B. Kester*

Rice Journal 54(4): 29, April 1951.

The method reported here for measuring the lipase activity in rice bran consists in titrating the acidity developed when an aqueous extract of the defatted bran is stirred in contact with the substrate, "Tween 20." It is useful for comparing the effectiveness of various stabilizing treatments. The lipase activity values of several fresh brans lie within the range of 0.19 to 0.35 milliequivalents of acid formed per minute per kilogram of bran.

### AIR CLASSIFICATION AND SIEVING OF RICE BRAN AND POLISH

*David F. Houston and Ali Mohammad*

Rice Journal 69(8): 20-21, July 1966.

Air classification of defatted and finely ground California Pearl rice bran or polish enriched protein contents in some of the fractions produced, but total improvement was too little to be useful. Sieve classification of defatted bran, however, yielded about 30 percent as a product with some potentials for food use.

### SOLUBILIZATION AND RECOVERY OF PROTEIN FROM DEFATTED RICE BRAN

*L. Chen and D. F. Houston*

Cereal Chem. 47: 72-79, 1970.

Alkaline extraction of defatted California rice bran removed 33.3 to 82.5 percent of total crude protein as pH increased from 7 to 12 when the bran was stirred 1 hr. at 25°C. with 7.5 volumes of extractant (optimal conditions). Grinding the bran had little effect, though solubilization of protein and total solids increased somewhat at and above pH 10. Much of the extracted protein was separated by isoelectric precipitation (pH 5.5); a further small amount was coagulated by heating. About 16 to 17 percent of total crude protein remained soluble after isoelectric precipitation; about half the nitrogen in this fraction was dialyzable. At pH 11, which was optimal, neutralization and drying of the extract yielded about 50 percent of the bran protein as a 40 percent concentrate. Drying of the separated solids precipitated at pH 5.5 from the pH 11 extract yielded about 37 percent of the bran protein as an 85 percent concentrate. Gel electrophoresis showed multiple components in both soluble and precipitated fractions of the extracted protein.

### MICROINCINERATION AND SCANNING ELECTRON MICROSCOPY: SILICA IN RICE HULLS

*R. S. Thomas and F. T. Jones*

Proc. 28th Annual Meeting, Electron Microscopy Society of America, Oct. 5-8, 1970, Houston, Texas, pp. 276-277, 1970.

Oxidation of rice hulls in a low-temperature plasma gave ash with preserved three-dimensional structure. Examination of the ash with a scanning electron microscope showed concentration of silica in the inner- and outermost surfaces of the original tissue, but some throughout.

### RICE HULL UTILIZATION

*Milton Staackmann*

Proc. Natl. Symposium on Food Processing Wastes, April 6-8, 1970, Portland, Oregon, pp. 387-390, Pacific Northwest Water Laboratory, Federal Water Quality Administration, Portland, Oregon, 1970.

(Contract research, URS Research Co., San Mateo, Calif.)

This paper summarizes the potentials of four concepts: (1) Portland cement; (2) waterglass; (3) porous silicate materials, and (4) architectural board. The possibility of combining concepts into one manufacturing complex is discussed. Results of this study are presented in more detail in the final report of this contract.

### ANIMAL FEEDS FROM VEGETABLE WASTES

*George O. Kohler*

Proc. Natl. Symposium on Food Processing Wastes, April 6-8, 1970, Portland, Oregon, pp. 383-386, Pacific Northwest Water Laboratory, Federal Water Quality Administration, Portland, Oregon, 1970.

This is a progress report on research being conducted to cope with environmental pollution from two types of agricultural waste. It is imperative that alternative disposal procedures to burning be developed for lignified cellulose materials, such as cereal straws, oilseed hulls, corncobs, etc. These materials can be made into animal feeds, if they are made more digestible by breaking down the cellulose and lignin by processing and by chemical treatments. The other type of waste is from green vegetables after they are prepared for the fresh market. The fresh leaves decompose rapidly and become a breeding ground for flies and create an odor problem. In working with cauliflower plants, it was found possible to compress, dry and separate leaf from stem and still retain enough carotene, xanthophyll, protein and fiber for a high grade poultry feed. The corresponding stem meal could be made into an excellent cattle feed. Feeding trials are now being carried out. Economic evaluations on straw products and cauliflower wastes are being made by computer with parametric linear programming techniques.

### RECOVERY OF LOW-FIBER PRODUCTS FROM DEFATTED RICE BRAN BY REMILLING AND SIEVING

*D. F. Houston*

Proc. 13th Rice Technical Working Group, Beaumont, Texas, Feb. 24-26, 1970, Texas A and M University, College Station, 1970.
Abstract of paper presented at the meeting.

### RICE HULL UTILIZATION. FINAL REPORT

*Milton Staackmann and Thomas C. Goodale*

Report No. URS 776-10, URS Research Co., San Mateo, Calif., 94402, Sept. 1970.
(Report of work done under contract to U.S. Department of Agriculture.)

The objective of this study was to identify industrial applications for rice hulls that are both technically and commercially feasible. From 15 utilization concepts evaluated, four hold the most promise: (1) Using rice hulls to supply a portion of the required silica and heat for reaction in cement plants appears technically and economically feasible for the Sacramento Valley area only (representing about 20 percent of total production of hulls). Such a plant may be capable of producing cement at a cost 1 or 2 cents per barrel lower than is possible in an ordinary plant. (2) Production of decorative architectural board by bonding rice hulls together appears technically feasible by a number of methods. The most promising bonding techniques are vulcanized fiber, chemical bonding by means of polybasic acids reaction with the cellulose of hulls, and physical bonding with sodium silicate. Complete technical and economic feasibility depends on solution of problems associated with these techniques. Production of rice hull board with sodium silicate as a binder appears to be economically feasible with the possibility of making a board 40 percent cheaper than wood product insulation board. (3) Manufacture of silicate structural materials by burning the hulls and bonding the resultant ash has technical promise through two approaches. One includes burning and bonding materials in one continuous kiln operation, while the other requires initial burning of hulls followed by a separate step of autoclave bonding the silicate material. Production of bricks with rice hull ash in a process similar to one using flyash is not economically feasible. (4) Using rice hulls to supply all the silica and heat for reaction in sodium silicate plants appears technically and economically feasible for all rice milling areas, but especially for the Sacramento Valley. For plants needing only minor modifications to facilitate use of rice hulls and for plants employing unconventional methods of producing sodium silicate, it appears this chemical can be made at a cost from 40 to 71 cents per ton lower than is possible in ordinary plants.

NEWS OF RICE. AN ANCIENT STAPLE
*E. B. Kester and J. W. Jones*
Yearbook of Agr. 1950-1951, pp. 362-366, 1951.
Brief discussion of rice in the U.S., the nutritional changes during milling, parboiling, and enriching with minerals and vitamins, types of rice products then available in the U.S. markets, and the research underway to improve and increase rice products for use by the U.S. consumer.

RESEARCH AND THE RICE INDUSTRY--CALIFORNIA
*W. L. Shaw, E. B. Kester, and O. R. Vasak*
Rice Journal 53(12): 6, 8-12, Dec. 1950
Review of the history, cultural requirement, varieties, production, and profits of rice grown in California. Milling industry, exports, and future possibilities of crop are discussed. Need for research and its possible benefits are pointed out.

RICE RESEARCH--WESTERN REGIONAL RESEARCH LABORATORY
Rice Annual, pp. 6-7, 79, 1952.
A review of rice research at WURB during the year 1951, including development of quick-cooking forms of rice, moisture equilibria and rice composition.

RICE RESEARCH--WESTERN REGIONAL LABORATORY
Rice Annual, pp. 6, 8-9, 1953.
A review of rice research at WURB during the year 1952, including paddy and parboiled rice storage, processed rice product stabilization, waxy rice flour, and canned rice.

RECENT DEVELOPMENTS IN PRECOOKED FROZEN FOODS
*H. L. Hanson*
Amer. Dietetic Assoc. 30(3): 241-244, March 1954.
A general review.

RICE INVESTIGATIONS AT WESTERN UTILIZATION RESEARCH BRANCH
*E. B. Kester and D. F. Houston*
Rice Annual, pp. 20-22, 1954.
A general review of the researches conducted on rice during the year 1953.

WAXY RICE FLOUR IMPROVES FROZEN CANNED FOODS
*Hans Lineweaver*
Rice Journal 57(10): 20, Oct. 1954.
Summarizes the value of waxy rice flour in stabilizing frozen sauces, gravies, custards, puddings and cake fillings, and in preventing viscosity changes in canned foods.

INVESTIGATIONS (ON RICE) AT WESTERN UTILIZATION RESEARCH BRANCH
*E. B. Kester*
Rice Journal 58(7): 42-45, Annual Issue, 1955.
A review of recent researches at this Branch on storage of rough rice, rice drying, composition studies, and studies of processed rice foods.

FROZEN COOKED RICE
*E. B. Kester and M. M. Boggs*
In "Precooked Frozen Foods," a symposium sponsored by the Quartermaster Food and Container Institute for the Armed Forces, Dec. 1955.
A review of earlier work on frozen cooked white and brown rice.

RICE INVESTIGATIONS AT WESTERN UTILIZATION RESEARCH BRANCH
*E. B. Kester*
Rice Journal 59(7): 43-47, 49, 52-53, Annual Issue 1956.
A review of rice research at WURB during the year 1955.

RICE INVESTIGATIONS
*E. B. Kester*
Rice Journal 60(7): 19-20, 22-24, 26, Annual Issue, 1957.
A review of rice research at Western Utilization Research and Development Division during the year 1956.

RESEARCH ON CEREALS AT THE WESTERN REGIONAL RESEARCH LABORATORY
*J. W. Pence and G. O. Kohler*
Cereal Science Today 3(9): 235-240, Nov. 1958.
The three main areas of research are the fundamental nature of proteins, lipids, and carbohydrates of wheat, rice, and barley; use of wheat and rice in foods; and use of wheat and barley and their products as feeds.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*E. B. Kester*
Rice Journal 61(8): 24-28, Annual Issue, 1958.
A review of rice research at Western Utilization Research and Development Division during the year 1957.

RESEARCH ON CONDITIONING AND STORAGE OF ROUGH AND MILLED RICE
U.S. Dept. Agr. ARS-20-7, processed, Nov. 1959.
a 55-page, illustrated and documented report in cooperation with Agricultural Marketing Service and Farmer Cooperative Service of the U.S. Department of Agriculture and four rice producing state experiment stations of work done through 1958 in the fields of drying and storing rice and preserving quality.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*Ernest B. Kester*

Rice Journal 62(7): 26, 28-30, Annual Issue, 1959.
A review of rice research in Western Utilization Research Division, Agricultural Research Service, U.S. Department of Agriculture during the year 1958.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*Ernest B. Kester*
Rice Journal 63(7): 28, 30, 32, 43, Annual Issue,1960.
A review of rice research in Western Utilization Research and Development Division, Agricultural Research Service, U.S. Dept. of Agr., during the year 1959.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*E. B. Kester, J. W. Pence, and G. O. Kohler*
Rice Journal 64(7): 46-47, 50, Annual Issue, 1961.
A review of rice research in Western Utilization Research and Development Division during year ending June 1961.

SECOND CONFERENCE ON RICE UTILIZATION
U.S. Dept. Agr. ARS-74-24, 31 pp., processed, Aug. 1961.
Contains abstracts of 21 speeches presented at the conference conducted by Southern and Western Utilization Research and Development Divisions in cooperation with Federal, State, and private agencies, May 18-19, 1961, Albany, California.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*Ernest B. Kester and James W. Pence*
Rice Journal 65(7): 45-47, Annual Issue, 1962.
A review of rice research at Western Regional Research Laboratory during the year ending June, 1962.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*David F. Houston, Ernest B. Kester, and J. W. Pence*
Rice Journal 66(7): 82-88, Annual Issue, 1963.
A review of rice research in Western Utilization Research and Development Division during the year ending June 1963.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*D. F. Houston, R. E. Ferrel, and J. W. Pence*
Rice Journal 67(7): 25-26, 28, 30, 32, Annual Issue, 1964.
A review of investigations during 1963 which have been directed largely towards more nutritious rice foods and evaluation of the relations between chemical composition and various properties of the rice products.

RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY
*David F. Houston and J. W. Pence*
Rice Journal 68(7): 34, 36-37, Annual Issue, 1965.
This is a review of investigations during 1964 directed largely toward practical production of more nutritious rice foods and collection of basic information on rice composition.

RICE INVESTIGATION AT WESTERN REGIONAL RESEARCH LABORATORY
*David F. Houston, A. I. Morgan, Jr., and J. W. Pence*
Rice Journal 69(7): 82-85, Annual Issue, 1966.
Rice investigations during the past year consisted of a continuing effort toward development of more nutritious, tasty, and convenient items for domestic or foreign consumption and basic research on rice characteristics necessary to support that effort.

RECENT RICE RESEARCH DEVELOPMENTS AT THE WESTERN REGIONAL RESEARCH LABORATORY
*J. W. Pence*
*In* Proc. National Rice Utilization Conference April 15-16, 1966, New Orleans, La.
U.S. Dept. Agr. ARS 72-73, p. 9-14, Jan. 1967.

*RECENT U.S. DEVELOPMENTS IN RICE HUSK UTILIZATION
*D. F. Houston*
*In* "Rice By-Product Utilization," Food and Agr. Organization of the United Nations Informal Working Bull. No. 30, Rome, Italy, pp. 13-16, 1967.
Rice husks are used industrially in fertilizers and furfural, for fruit juice filtration, blast cleaning, and tumble polishing and burnishing of metal and plastic. Sugars produced by hydrolysis of husks offer promise for fermentation processes. In California, many husks are burned in outdoor stacks to provide ash that is used as a grease-absorbing sweeping compound or in mechanics hand soap. Agricultural uses include feed roughage, animal bedding, and poultry litter and nesting material. Prospects for large-scale industrial uses are not encouraging.

UTILIZATION OF RICE HUSKS
*David F. Houston*
*In* "Rice By-Product Utilization," Food and Agr. Organization of the United Nations Informal Working Bull. No. 30, Rome, Italy, pp. 7-11, 1967.
Rice husks are the largest byproduct of the world rice milling industry. Many studies exist on their utilization and economic value. Compositional studies reveal possibilities for use in agriculture and industry. Some successful uses include fuel for boilers, the ash from which is used in sweeping compounds, insulation, for brick, animal bedding and feed as well as in the manufacture of boiler linings and ceramics.

### RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY

*David F. Houston, I. Wasserman, and J. W. Pence*

Rice Journal 70(7): 94-98, Annual Issue, 1967.
A review of rice research at Western Utilization Research and Development Division during 1966.

### RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY

*David F. Houston, I. Wasserman, G. O. Kohler, and J. W. Pence*

Rice Journal 71(7): 62-63, 65-67, Annual Issue, 1968.
Brief summaries of investigations during the 1967-68 year include further evaluation of the WRRL rice sample dryer, determination of amino acid contents of rice milling products and studies on rice proteins. The composition studies have emphasized the coproducts of milled rice in order to accumulate information helpful in upgrading their use.

### RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY

*David F. Houston and J. W. Pence*

Rice Journal 72(7): 36, 38-39, July 1969.
Studies during the year 1968 have dealt with problems pertaining to proteins of rice and its milling byproducts. Included is research on wet and dry procedures for recovering food-grade protein or protein concentrates from bran and on comparison of proteins occurring in bran and milled rice.

### NUTRITIONAL PROPERTIES OF RICE

*D. F. Houston and G. O. Kohler*

Prepared for the Food and Nutrition Board, National Research Council, National Academy of Sciences, Washington, D. C., 65 pp., 1970.
This review furnishes the background and present situation of rice as food for more than half the world's population. Composition, nutritive adequacy and availability, enrichment and supplementation of rice and its milling products are covered. Effects of processing and cooking on nutritive values of products, special dietary values and problems, and areas for future research are also discussed. A bibliography of 228 references is included.

### RICE INVESTIGATIONS AT WESTERN REGIONAL RESEARCH LABORATORY

*D. F. Houston and D. A. Fellers*

Rice Journal 73(7): 43-46, July 1970.
A review of rice research at WURDD during the year ending June 1970, including work on increased utilization of straw, hulls, and bran, and on examination of rice and bran composition and characteristics.

### WRRL CONTRACT RICE RESEARCH

*D. F. Houston*

Progress Report to the California Rice Industry, p. 38-39, July 1970.
Abstract of paper presented at the Rice Research Extension Symposium, University of California, Davis, California Jan. 7-8, 1970.

# PATENTS

### STABILIZATION OF BROWN RICE

*E. B. Kester*

U.S. Patent No. 2,538,007, January 16, 1951. Brown rice is extracted briefly with hexane to remove freely soluble oil, leaving the "residual" majority of the oil in a relatively stable condition and giving improved storage properties to the rice.

### PREPARATION OF NOVEL FOOD PRODUCTS

*R. L. Roberts*

U.S. Patent No. 2,585,036, February 12, 1952. Rice meal passing a 16-mesh sieve is mixed to a paste with 3/4 to 1 part of hot water, extended into an elongated shape 1/8 to 1/4" in diameter, and cooked in oil at about 375°to 425°F to form a snack item.

### METHOD OF STABILIZING RICE PRODUCTS

*G. R. Van Atta, E. B. Kester, and H. S. Olcott*

U.S. Patent No. 2,585,978, February 19, 1952. Rough rice at harvest moisture is heated at 185° to 212°F with moist gas for 1/2 to 15 min. to inactivate lipases present but not to cook or discolor the rice or reduce its milling quality, after which it is dried and dehulled to provide a relatively stable brown rice.

### PRODUCTION OF QUICK-COOKING RICE

*R. L. Roberts*

U.S. Patent No. 2,610,624, September 9, 1952. Rice is cooked to contain about 45 to 55% water, then dried partially in an air stream at 170 to 250°C with sufficient air velocity to suspend and tumble the grains. The partly dried product containing a multitude of small voids is then farther dried with an air stream at about 100 to 150°C. to give a rapidly rehydrating product.

### PRODUCTION OF EXPANDED RICE PRODUCTS

*R. L. Roberts*

U.S. Patent No. 2,616,808, November 4, 1952. Preparation of ready-to-eat products by heating a pregelatinized rice of 8 to 14% moisture content in air or oil at about 170 to 250°C. The product is a crisp, porous expanded grain with 2 to 6 times the volume of the original rice.

### STABILIZED CREAMED FOOD PRODUCTS

*H. L. Hanson and H. Lineweaver*

U.S. Patent No. 2,653,876, September 29, 1953. A cooked food product of sauce-like to custard-like consistency comprising an edible liquid thickened with a starchy material of which at least 20% is waxy rice, the product being characterized by the fact that it will exude no watery liquid and will maintain a smooth and creamy texture when frozen and thawed.

U.S. Patent No. 2,686,130, August 10, 1954. Rice is soaked and cooked to about 45 to 60% moisture content and filled into cans. The cans are subjected to high vacuum and sealed under vacuum. Can and contents are finally subjected to a heat processing to sterilize the contents and the inside of the container.

### PREPARATION OF PRE-COOKED RICE

*R. L. Roberts*

U.S. Patent No. 2,715,579, August 16, 1955. Patent concerns production of dry, precooked rice in the form of porous, readily rehydratable grains. The product is added to boiling water and is ready for serving in 1 to 3 minutes. Preparation involves first soaking raw white rice in water until its moisture content is 25-35%. The soaked rice is steamed to gelatinize the starch without substantial increase in moisture content. The steamed rice is dried in two temperature stages--first at 35-100°C. and then at 200-260°C. The second stage of drying causes expansion of the grains to ensure formation of porous grains.

### METHOD OF PREPARING PRE-COOKED PUFFED BROWN RICE CEREAL

*E. B. Kester and R. E. Ferrel*

U.S. Patent No. 2,785,070, March 12, 1957. Brown rice is soaked in water, cooked, partly dried, and then subjected to a toasting action by treatment with a current of hot air (250-300°C.) to develop a product with a nutty flavor. The product is ground to a meal which forms a tasty cereal when mixed with warm milk.

### PROCEDURE FOR PREPARING CANNED RICE

*R. E. Ferrel*

U.S. Patent No. 2,898,214, August 4, 1959. Improved process for canning rice wherein partially cooked rice, prior to filling into the cans, is coated with an aqueous dispersion of an ester of a polyhydric alcohol and a fat acid, for example, sorbitan monoleate. This coating operation prevents the rice grains from adhering to one another or to the can walls.

### METHOD OF CANNING RICE

*R. E. Ferrel*

U.S. Patent No. 2,898,215, August 4, 1959. Improved process for canning rice wherein partially cooked rice, prior to filling into the cans, is coated with an aqueous emulsion containing an edible oil and an emulsifying agent. This coating operation prevents the rice grains from adhering to one another or to the can walls.

### PROCESS FOR INCREASING MILLING YIELDS OF RICE

*Theodore Wasserman and R. E. Ferrel*

U.S. Patent No. 3,089,527, May 14, 1963.
Prior to milling, rough rice is dried to a moisture content lower than in conventional practice, i.e., 10 to 11 percent instead of 12 to 13.5 percent. This change in processing provides higher yields of milled rice.

### COATED RICE

*R. E. Ferrel*

U.S. Patent No. 3,384,493, May 21, 1968.
Rice having a glazed appearance is prepared by coating white rice with corn syrup and a selected agent--typically calcium acetate, citrate, or lactate--which provides the desired sheen.

# AUTHOR INDEX

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